USING PARA RUBBER MIXED IN MODERATE LIGHTWEIGHT CONCRETE

Prachoom Khamput*

Abstract:
This research is to use latex from para-rubber as an admixture for improving the strength and insulation properties of autoclaved aerated lightweight concrete. In mix design, cement-sand ratio is 1:1 (by weight). The aluminum powder (3% by weight) is added, water-cement ratio is 0.5 (by weight not include water in latex), five percent of lime and gypsum (by weight of cement) are added. To provide latex from para-rubber, the solution of ammonia at 15% of concentration is added into para-rubber at amount of 3% (by weight of para-rubber). Concrete must be added 4% (by weight of cement) of the nonionic surfactant. The latex per cement ratios that use in this experiment are 0, 0.10, 0.15 and 0.20 by weight of cement. Then mixing and streaming follow TIS (Thailand Industrial Standard) and test the density by volume, compressive and bending strength at ages of 3, 7, 14 and 28 days. The absorption of water is measured at 7 and 28 days. The elongation and coefficient of thermal conductivity are measured under ASTM standard. From the results, it is found that the compressive strength and density of lightweight concrete reverses variation with latex-cement ratios while the bending strength and water absorption of concrete is Propostion to latex-cement ratio. The elongation has an uncertainty for each latex-cement ratio. The coefficient of thermal conductivity is slightly larger than normal lightweight concrete. The suitable latex-cement ratio is 0.10 (by weight of cement). By consider all of results, this can be produced as a moderate lightweight concrete in which high strength and good insulation are highlighted.

Introduction
Thailand had area of planting para-rubber trees around 20,000 Km² and exporting value was around 131,617,514 million baths per year [2]. There were 7 million people of farmers that had occupation about para-rubber in the country. This cause the para-rubber to be the main income of the country. The application of para-rubber in many products was largely increased from 250,000 tons to 500,000 tons in year of 2006 [3]. By previous reason, the government encouraged the planting of para-rubber trees in north-east area of the country and waited for the products in the next 2-3 years. Although, para-rubber gave high rate of price, 100 baths/kg, and average price was around 76 baths/Kg but para-rubber was the primary product that can be replaced by the other products

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Preparation of the specimens: Prepare latex from paraffin by using 3% (by weight of paraffin) \[ \text{latex} \] of an ammoniacal solution that has concentration of 15% cement powder type I (see TBS standard [1]), lime under standard of TBS 1743/1971, gypsum, lime sand that passes sieve 8/500, aluminum powder, monosodium silicate, and water.

Preparation of the specimens:
1) Assign the fixed ratio for cement and water, which is 1:1 by weight, aluminum powder is 3% of total ingredients, water: cement ratio is 0.5, 0.6 by weight (not include the weight of water in latex), lime is 5% by weight of cement. The latex is prepared from adding 3% ammoniacal solution (concentration of 15%) by weight of paraffin and 4% of monosodium silicate by weight of cement.

2) The variable parameters is the latent cement ratios (LPC), which equal 0, 0.2, 0.4, 0.6, 0.8, and 1.0 by weight of cement.

3) Cast the blocks into lightweight cement and blocks specimens followed with TBS 1505-2541 [8].

4) Test the density under TBS 1505-2541 [8].

5) Test the absorption of this type of concrete blocks under TBS 1505-2541 [8].

6) Test compressive strength by TBS 1505-2541 [8].

7) Test the setting time by ASTM C626 [9].

8) Test the abrasion of this type of concrete blocks under TBS 1505-2541 [8].

9) Test the thermal conductivity of this type of concrete blocks by ASTM C177 [10].

Results and Discussion

10) Density by volume:

From Fig. 1, it is found that density reverses proportion to the age of lightweight concrete. Initially, all of the ingredients (cement, sand, lime, gypsum, powdered aluminum, and water) are mixed together. There are many reactions that occur, which results in a hardening of the concrete. The density reaches its maximum value at an age of 28 days. This is because the particles of the concrete are closely packed together, resulting in a higher density. As the concrete ages, the density decreases due to the formation of air voids and the settling of the particles. This is why the density decreases as the age of the concrete increases.

![Relationship between age and average density of concrete](image)

From Fig. 2, we see that the density of the lightweight concrete with various values of latent cement ratios. It is found that there is no difference in the density at 3 days, and the density decreases as the latent cement ratio increases. At 28 days, the density reaches its maximum value with a latent cement ratio of 0.8. This result is significant because it shows that the addition of lightweight concrete can improve the density of the final product.

This results from using water content of 55% in latex [13].
The water content in latex is mixed with aluminum powder and results in increasing the bubble in concrete. This leads to the reduction in density of concrete when latex cement ratio is increased.

![Fig. 2: Relationship between latex cement ratio and density](image)

![Fig. 3: Relationship between age and water absorption of concrete](image)

![Fig. 4: Relationship between latex cement ratio and water absorption of concrete](image)

3) Water absorption

From Figs. 3 and 4, it is found that water absorption at an age of 7 days is less than water absorption at 28 days for every ratio of L/C. This is because at an age of 7 days, there is less water in concrete. The hydration reaction is not complete; however, at 28 days, the reactions of water and cement and water and aluminum powder is complete and succeeded. This results in many bubbles in content of concrete which means increasing porosity. The increasing porosity affects the increasing of water absorption. As can be observed from Figs. 3 and 4, when latex is not added, the water absorption is high but when latex is added the water absorption will be decreased.

Because latex forms the thin film (polymer type) of polymer in content of concrete and makes the high density of concrete decreasing the bubble and low penetration of water. However, because of water content in latex, the amount of latex will not provide the decreasing of water absorption. There is an optimum point of latex cement ratio (L/C) that makes the lowest value of water absorption. This is latex cement ratio (L/C) of 0.15.

![Fig. 5: Relationship between age and compressive strength of concrete](image)
From Fig. 6, the compressive strength reverses proportion to latex-cement ratio (P/C). The maximum compressive strength is 115.64 ksc when latex-cement ratio P/C equals 0.10 and descending into 98.03 and 69.61 ksc for latex-cement ratios of 0.15 and 0.20, respectively. However when latex is not added into concrete, the compressive strength is lowest. This conflicts with the previous results in which compressive strength reduces as latex-cement ratio increases. This may be the effect of the thin film in the concrete when latex is added. According to the previous results that the optimum point of maximum density is P/C = 0.10, this leads to maximum compressive strength at this point. When latex-cement ratios are 0.15 and 0.20 the compressive strength is reduced because these points are not optimum point of density. This indicates that the suitable point of adding latex into concrete is P/C = 0.10.

![Graph](image)

Fig. 6 Relationship between latex-cement ratios and compressive strength of concrete

4) Tensile strength (in term of modulus of rupture)

From Fig. 7, the modulus of rupture of lightweight concrete at edge wise is larger than flat wise due to larger depth of lightweight concrete. The modulus of rupture increases as age of lightweight concrete increases and linear proportion to latex-cement ratios (opposite with compressive strength). This is the effect of thin film that performs as binding agent [13]. This thin film is formed as layer that reinforces the concrete for resisting the tensile load in concrete. Then increasing in modulus of rupture is the result.

![Graph](image)

Fig. 7 Relationship between age and modulus of rupture of concrete

5) Elongation of concrete blocks

From table 1, every specimen has elongation over 0.05% (0.05% is the standard of TIS 1505-2541 [8]). The closest value to the standard is 0.054 for latex-cement ratio at 0.10. The maximum value of elongation is 0.308% for latex-cement ratio at 0.20. This large elongation may affect the crack of the wall when loads are transferred. This may be the cause of the irregular distributed bubbles in the content of concrete or high flexibility of para-rubber which must be investigated and solved this problem in the future.

<table>
<thead>
<tr>
<th>Latex-cement ratios (P/C)</th>
<th>Sample no.</th>
<th>% of elongation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>1</td>
<td>0.071</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.139</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.139</td>
</tr>
<tr>
<td>0.15</td>
<td>1</td>
<td>0.146</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.244</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.180</td>
</tr>
<tr>
<td>0.20</td>
<td>1</td>
<td>0.054</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0.064</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.308</td>
</tr>
</tbody>
</table>
6) The coefficient of thermal conductivity

The results which are obtained from Department of science service, Ministry of Science and Technology are shown in Table 2.

<table>
<thead>
<tr>
<th>Latex-cement ratios (P/C)</th>
<th>Coefficient of thermal conductivity (Watt/M-Kelvin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.154</td>
</tr>
<tr>
<td>0.15</td>
<td>0.175</td>
</tr>
<tr>
<td>0.20</td>
<td>0.197</td>
</tr>
</tbody>
</table>

From Table 2, the coefficient of thermal conductivity is slightly higher than normal lightweight concrete [14]. The highest value of coefficient of thermal conductivity is 0.197 Watt/M-Kelvin for latex-cement ratio of 0.20. The coefficient of thermal conductivity decreases as latex-cement ratio decreases. This shows that adding the little value of latex will improve the insulation property. This paradoxes with previous results that the density of lightweight concrete reaches the maximum value when uses a little value of latex in which, normally, high density materials have low insulation property (high coefficient of thermal conductivity) [1]. Reside, a large number of thin films when the latex is increased, these thin films infiltrate the space of bubbles then the number of bubbles reduce and density increases which result in high coefficient of thermal conductivity.

Conclusions

The conclusions of the results are as follows:

1) The density reverses proportion to latex-cement ratios; increasing in latex decreasing in density.

2) Water absorption is proportion to latex-cement ratios; increasing in latex increasing in water absorption.

3) The compressive strength reverses proportion to latex-cement ratios.

4) The tensile strength (in term of modulus of rupture) is proportion to latex-cement ratios.

5) Elongation must be located in pending state due to the results did not directly indicate the effect of latex to elongation (fluctuation of the results). However we can tell that the elongation decreases as latex increases.

6) Thermal conductivity increases as latex increases.

7) Type of failure in this test is tensile failure.

References


[12] S. Chaikaewratchivit. *Rubber technology*, Department of material science, Faculty of science, Chulalongkorn University, Bangkok, 2548 (in Thai).

